WBS 6.5.2.4, 6.5.4.4 Low Voltage Power Supply Production and Box Assembly Technical Overview

Haleh Hadavand Dhiman Chakraborty

UT Arlington Northern Illinois University

Conceptual Design Review of the High luminosity LHC Detector Upgrades
National Science Foundation
Arlington, Virginia
March 8-10, 2016

LVPS Production

LVPS Production Expert

- Haleh Hadavand, Assistant Professor of Physics, has been part of the ATLAS experiment since 2005
- Integral part of Cosmics commissioning online and offline monitoring for the LAr Calorimeter in close collaboration with the Tile Calorimeter community
- Developed ATLAS' Data Quality Monitoring software and installed and integrated system for Calorimeter use
- Charged Higgs Convener for the ATLAS collaboration
- Recent addition to Tile Calorimeter

UT Arlington

- Physics Personnel:
  - Faculty: Haleh Hadavand (LVPS), Andrew Brandt (LVPS)
  - Graduate H. Akafzade and undergrad students
- Engineering Personnel:
  - Faculty: Ali Davoudi, EE
  - Electrical Associate: Seyedali Moayedi
  - Electrical Technician: Michael Hibbard

LVPS Requirements

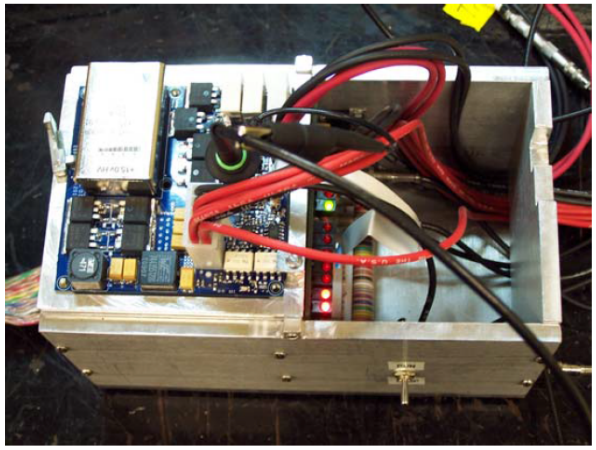


Figure 5. Picture of a brick test fixture

Figure 8. Close-up view showing connectivity of a brick in the Burn-in Station

Fig. 1. TileCal Module

Fig. 2. Electronics drawer

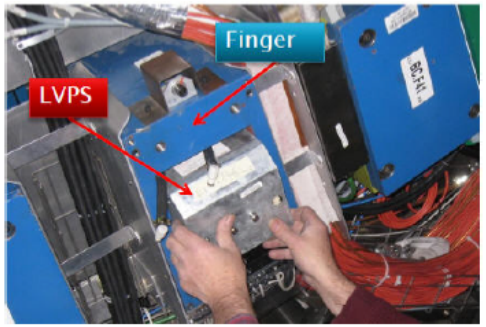
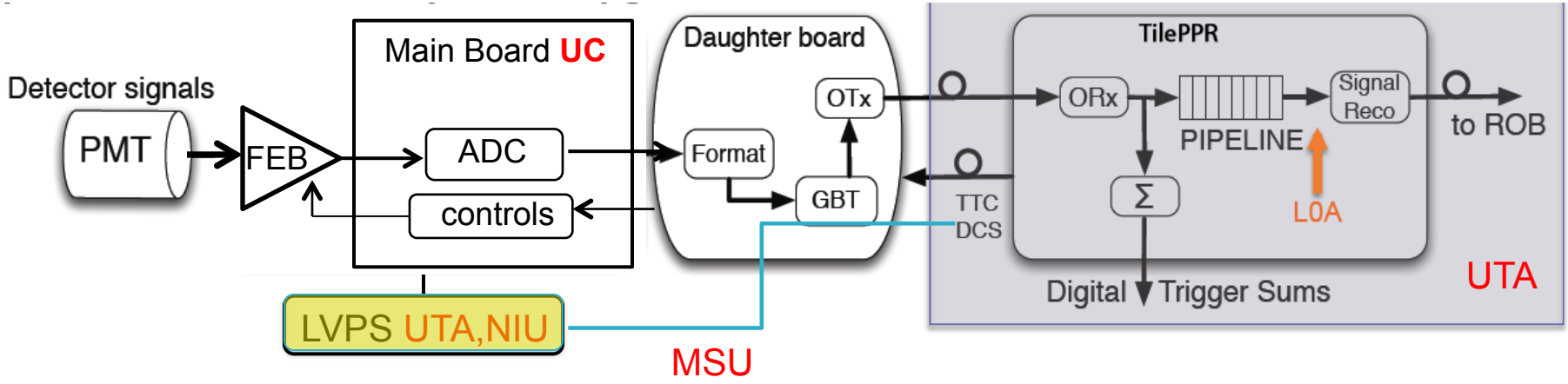


Fig. 3. LVPS mounted on module

Requirements: Vout 10 V, 7 A nominal, 14 A redundancy, 11A over voltage protection

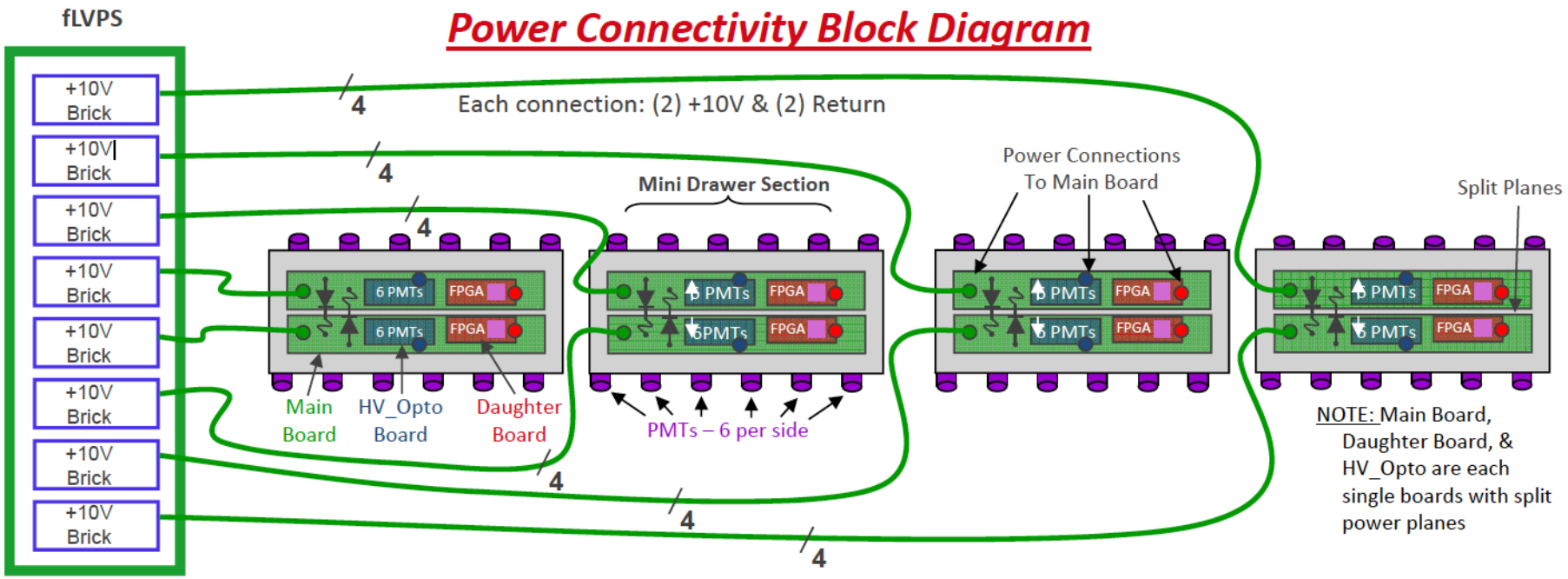
Front End Electronics



- 3-in-1 Front-end boards: Shaping of PMT signals for digitization, calibration and luminosity monitoring
- Main board: Digitize shaped PMT pulses, control attached 3-in-1 Front-end boards, power management from LVPS
- Daughter board: High speed link to the off-detector electronics for commands, On-detector monitoring / control and LHC clock extraction and distribution
- PPR: Off detector data stored in pipeline for trigger decision, interface to DAQ, and DCS

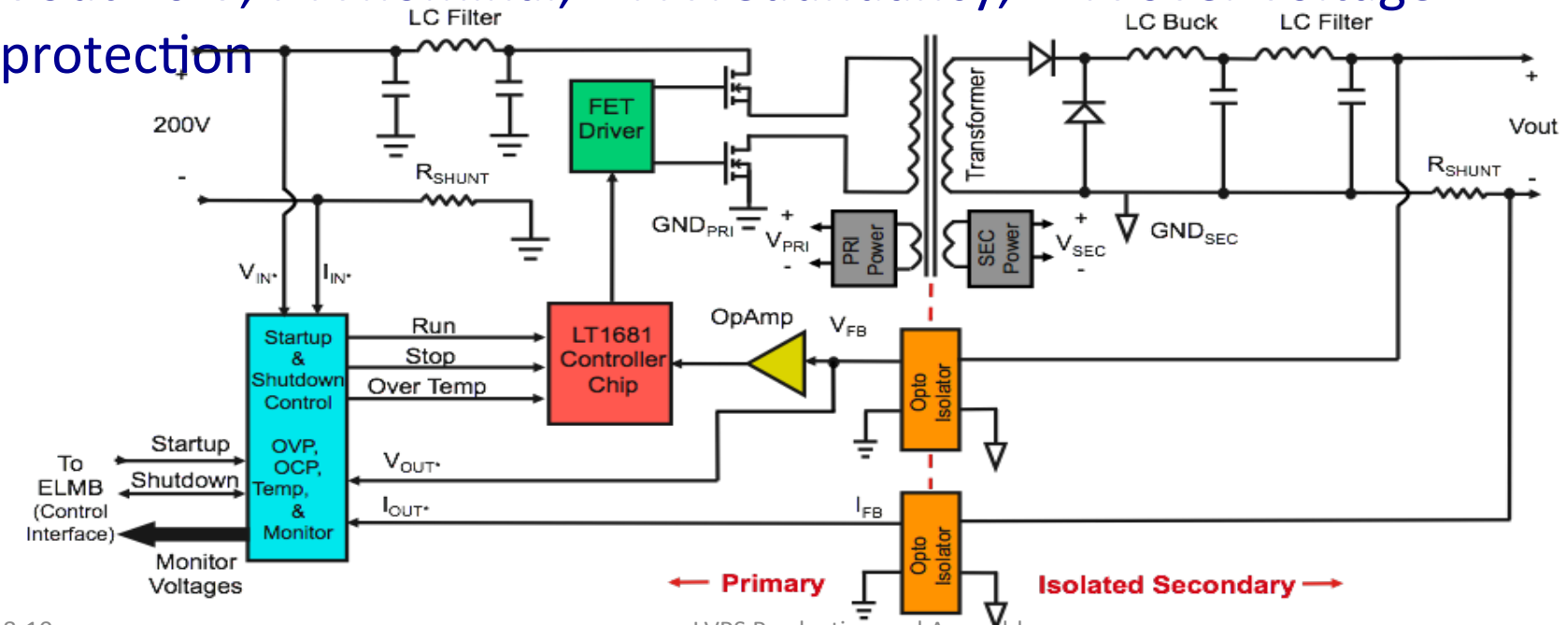
Power Connectivity

- Each power brick provides power to half a mini drawer
- However each brick capable of powering entire mini drawer through diode or in main board



LVPS Schematic

- Buck Convertor with transformer
- Controller chip operates at 300 kHZ
- 10-30% Duty cycle
- transformer winding of 14:2
- Vout 10 V, 7 A nominal, 14 A redundancy, 11A over voltage protection



LVPS Plans

- Major R&D phase completed by Argonne National Labs (ANL) under Gary Drake and Jimmy Proudfoot
- Transition of knowledge from ANL to UTA in progress
- Setting up test stand now and to get several bricks from Argonne
- Pre-pre-production of 8 bricks to happen in a few months
  - Use test stand for checkout and burn in
- Pre-production of 10%+1%(failure rate) of bricks (111) to happen in 2018
- Production of half of total bricks, 1024, to start in latter half of 2020 and lasts for ~2 years
- Send bricks to Northern Illinois University to be assembled into boxes

BOE for LVPS Production

- Labor: Based on labor from version of bricks in detector but with adjustments for UTA to ramp up expertise and to compensate for personnel overturn
  - Parts procurement
  - Basic checkout and burn in
  - Repairs to 10-20% of bricks
  - Management of project
- Material : Very good estimate from cost of brick production for the Demonstrator
  - Stock parts
  - Transformer
  - Thermal post
  - PCB Fab and Assembly
  - Test Stands
- Travel: Going onsite to vendors for procurement and instructions for fabrication and assembly

LVPS Box

Box Assembly Expert

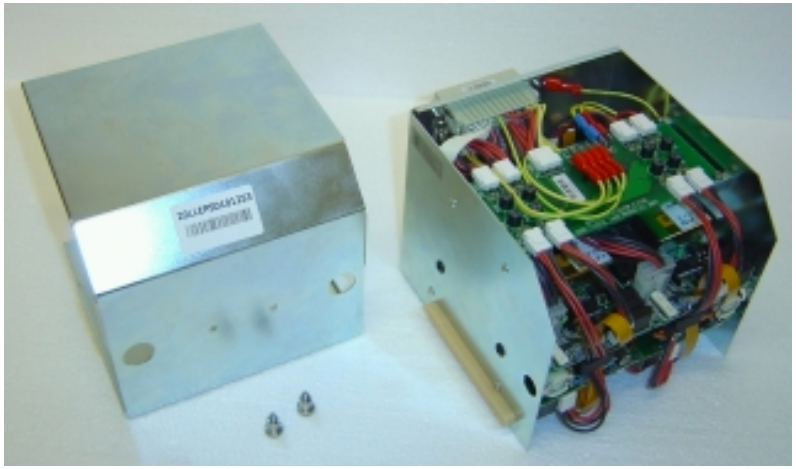
- Dhiman Chakraborty, Professor of Physics, Northern Illinois University
- Member of ATLAS and the Tile Calorimeter team since NIU joined in 2007
- US ATLAS Level-3 manager for Tile Calorimeter Calibration Database (2012-present)
- In charge of NIU's institutional responsibilities on ATLAS TileCal (next nu). Other current members of the TileCal group at NIU are
  - Iuori Smirnov (Research Scientist),
  - Pawel Klimek (Post-doc),
  - Blake Burghgrave (Graduate Student),
  - Puja Saha (Graduate Student).
- Will have additional personnel to help on this project
  - Electrical Engineer (Nicholas Pohlman OR suitable alternative)
  - Electrical Technician (Alexandre Dychkant OR Kurt Francis)
  - Undergraduate students (to be named)

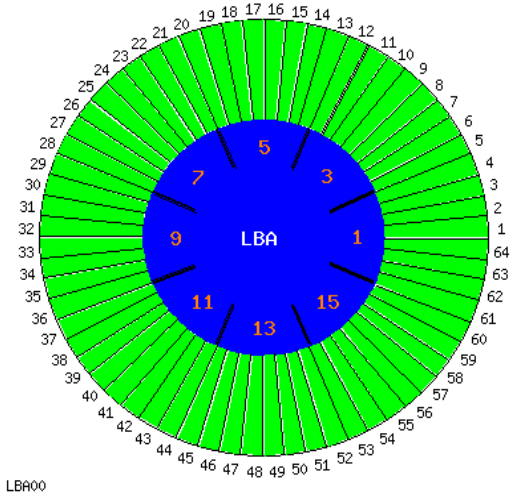
Northern Illinois U

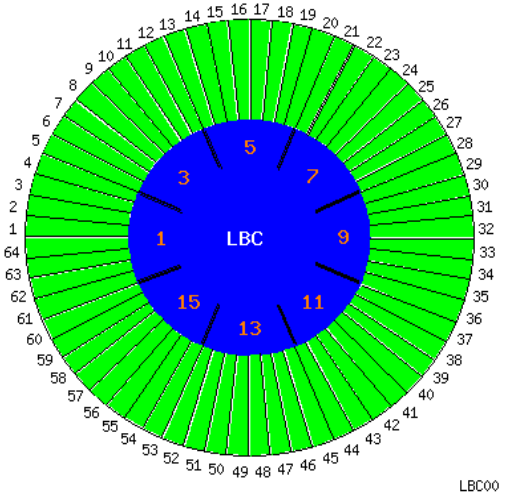
- The NIU ATLAS group has been participating in TileCal tasks since joining the collaboration in 2007
  - Institutional responsibilities in software projects (hardware done by then).
  - Contributed to the development and coordination of the Data Quality Monitoring system for online and offline use, signal reconstruction.
  - Full responsibility for maintenance, continued development, and user support for the TileCal calibration (conditions) database.
  - Scientists and grad students serve(d) in leadership roles on TileCal operations and maintenance.
- NIU is interested in contributing to hardware development for the HL-LHC upgrade. Have
  - In-house experience
  - Strong support from University, Northern Illinois Center for Accelerator and Detector Development

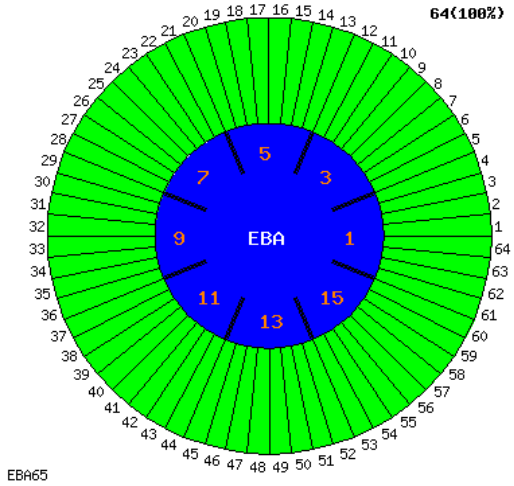
TileCal LVBOX deployment

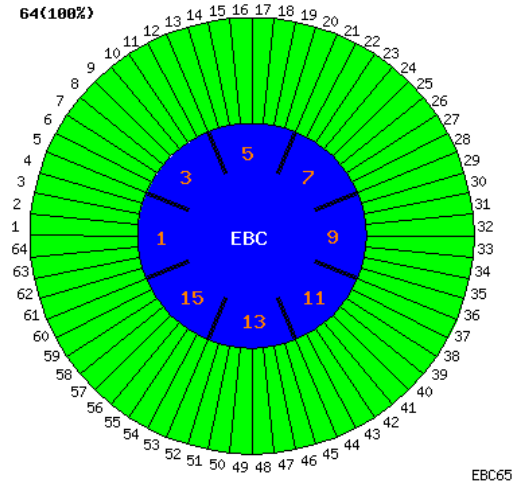
Low Voltage power to each module (in green) is supplied by one "box" containing: 8 independent DC/DC converters (bricks), an **ELMB Mother-board**, an **ELMB module**, 200V DC distribution **Fuse Board**, **internal cable set**, and **chassis** and a water cooled heat sink.





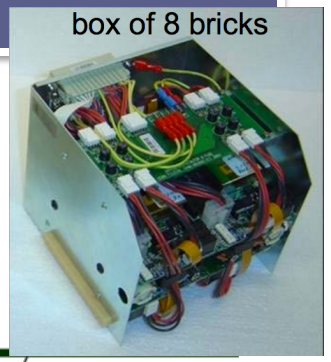






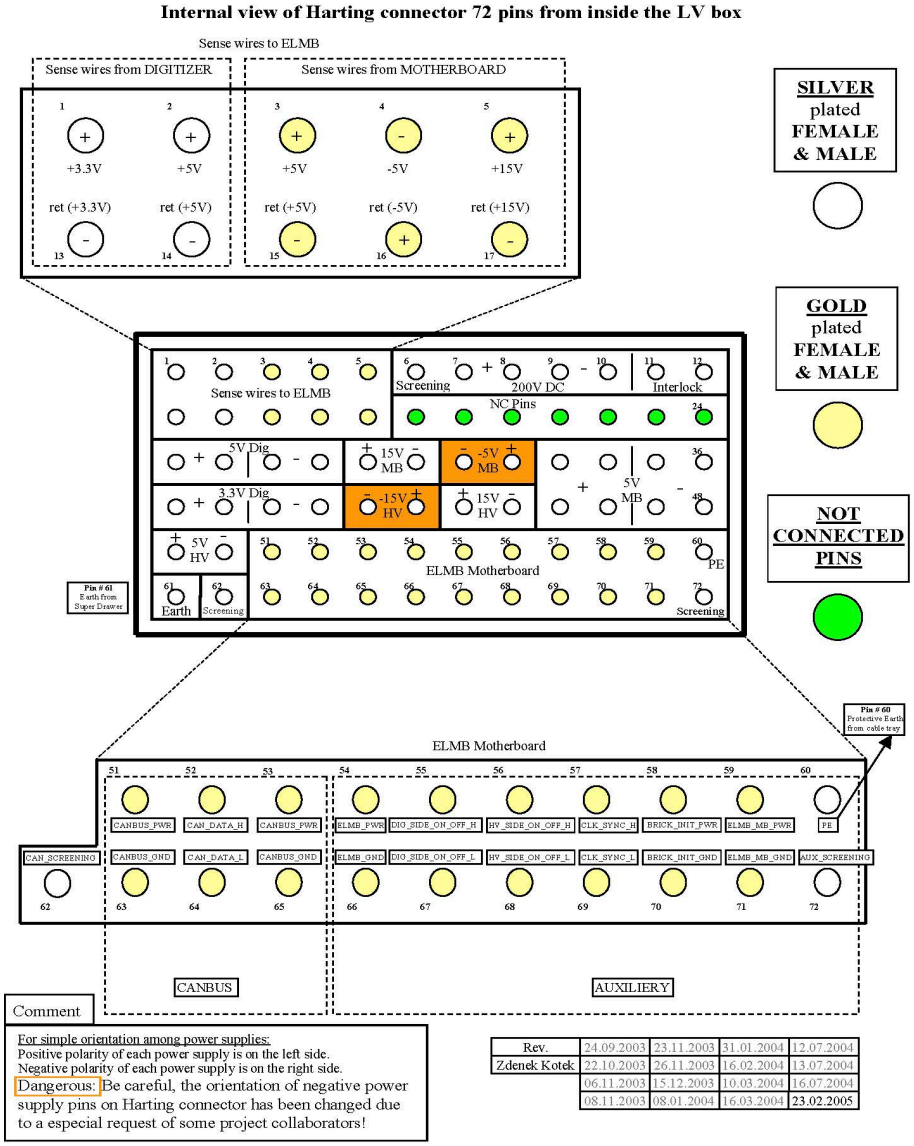
LVPS Box

Use same 72 pin
Harting Connector

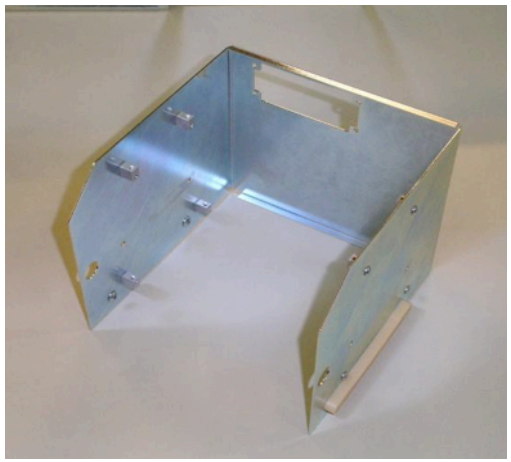


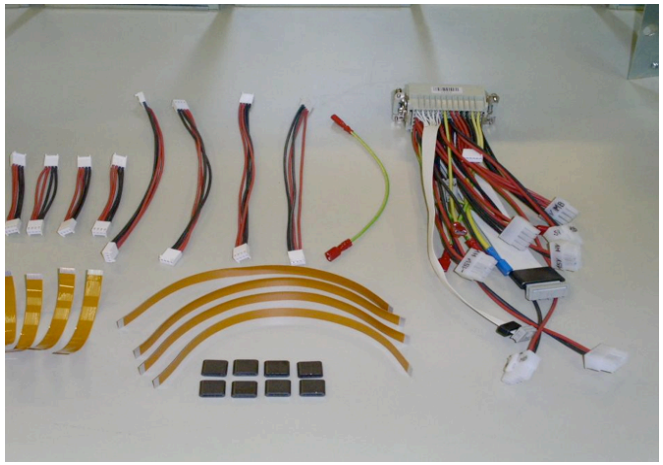
Range of Voltages: 1:1 ⇨ **One Brick Design**
Range of Currents: ~2:1 * ⇨ **Factor of 2 for redundancy**

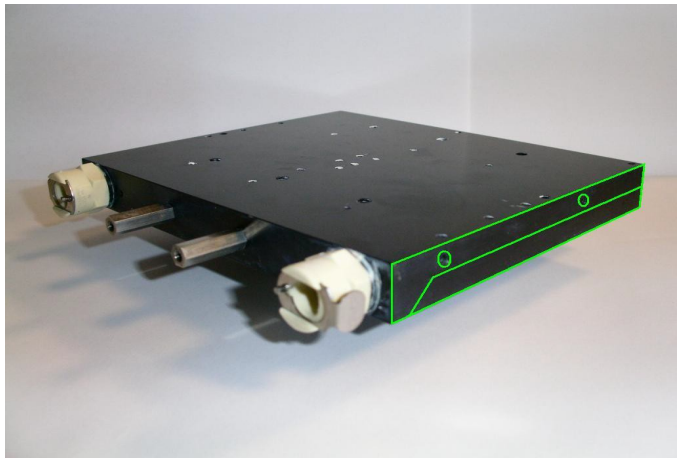
LVBOX I/O connections

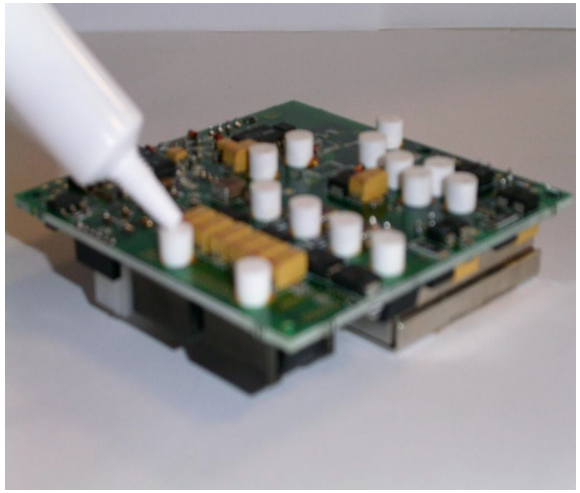


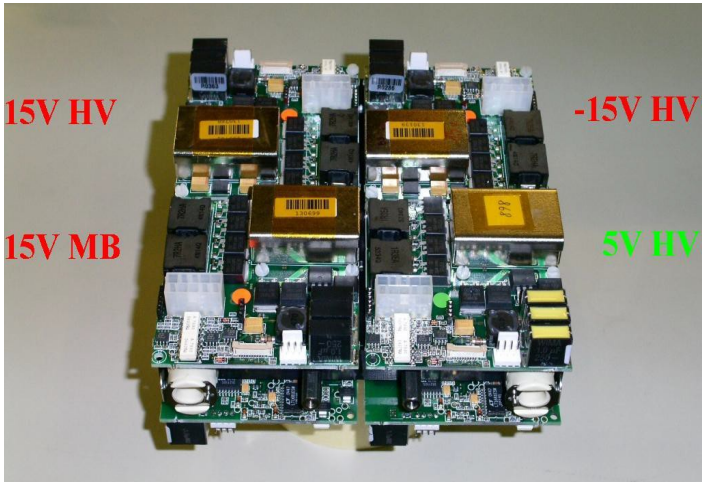
LVBOX assembly from components

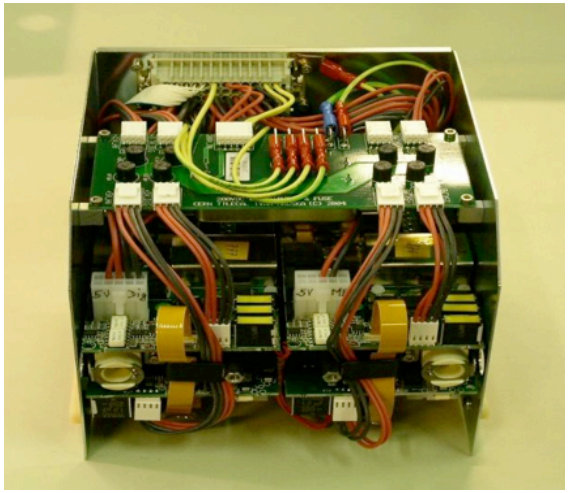












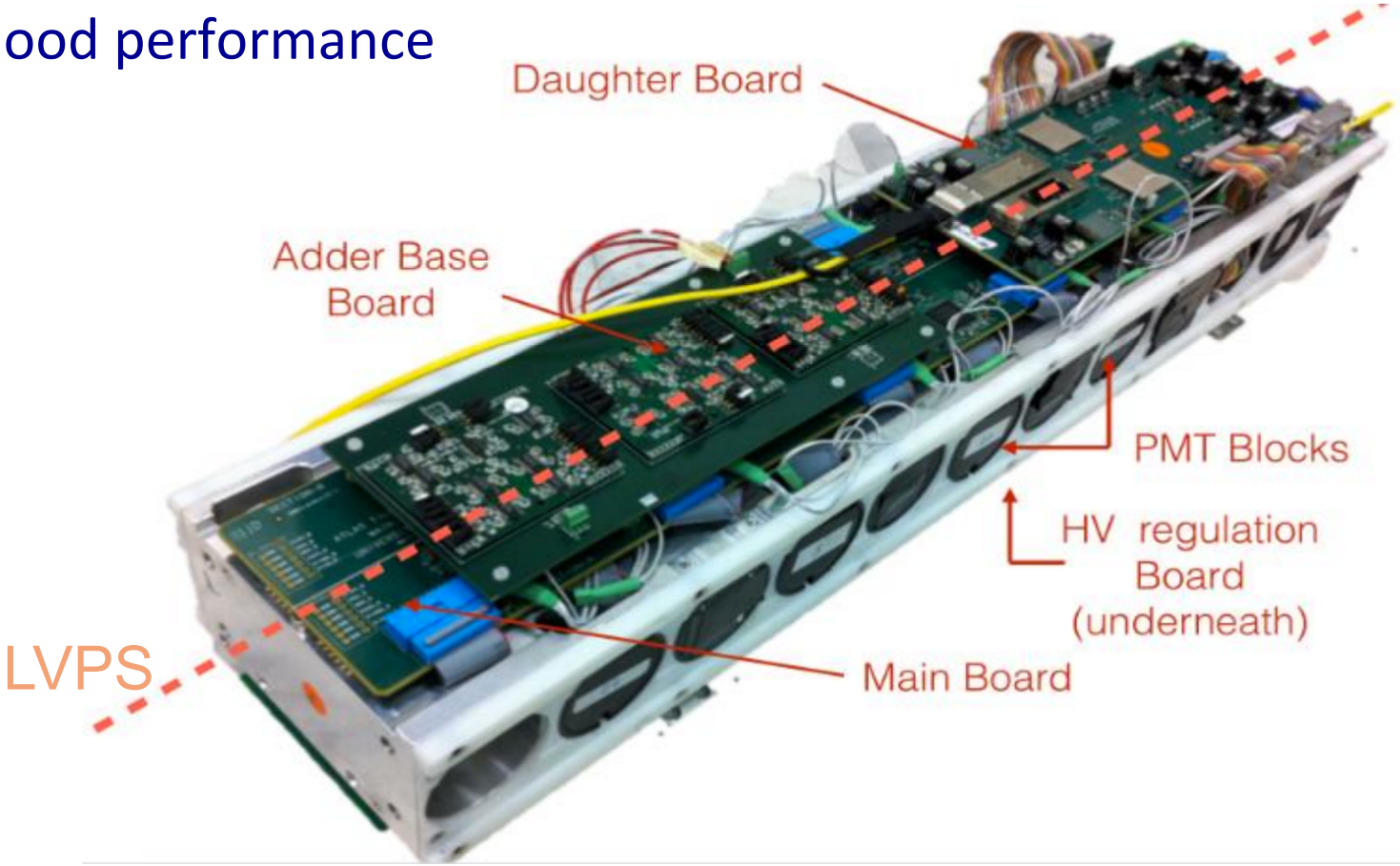
- LVPS “box” V7.5 assembly done at CERN by CERN/Prague
- V8 for HL-LHC will be similar, production shared 50-50 by NIU and Prague

BoE for LVBOX production

- Labor: FTE estimates based on experience from previous campaigns. NIU components are
  - Vendor selection, component selection, BoM
  - Burn-in and basic check-out (of half of the total of 256 boxes)
  - Diagnose and repair failures
  - Inventory, crate and ship to CERN
- Material: estimates based on procurement for v7.5
  - For maximum uniformity**,** procurement of each component is assigned to a single institution.
  - NIU will procure the fuse boards, connectors and cables, including fabrication.
  - A test-stand and burn-in station will have to be set up at NIU.
- Travel: for pre-production at CERN

Demonstrator

- Version 8.0.8 installed
- Good performance



Backup

WBS 6.5.4.4

WBS	Deliverable	Task	Labor Hrs	Labor $	M&S $	Travel $	Total $
6.5.4.4	**LVPS Assembly**		**2,526**	**232,419**	**193,950**	**19,275**	**445,644**
	Final design	LV4010	355	44,306	0	3,855	48,161
	Engineers		355				
	Technicians		0				
	Student labor		0				
	Preproduction procurement	LV4020	355	44,306	18,750	0	63,056
	Engineers		355				
	Technicians		0				
	Student labor		0				
	Preproduction assembly	LV4030	80	7,196	0	3,855	11,051
	Engineers		40				
	Technicians		40				
	Student labor		0				
	Preproduction burn-in and checkout	LV4040	80	7,196	0	7,710	14,906
	Engineers		40				
	Technicians		40				
	Student labor		0				
	Preproduction diagnostics and repair	LV4050	80	7,196	0	0	7,196
	Engineers		40				
	Technicians		40				
	Student labor		0				
	Test equipment	LV4060	480	44,470	20,000	0	64,470
	Engineers		240				
	Technicians		240				
	Student labor		0				
	Production procurement	LV4120	136	10,593	128,000	0	138,593
	Engineers		40				
	Technicians		96				
	Student labor		0				
	Production Assembly	LV4130	120	10,045	0	3,855	13,900
	Engineers		40				
	Technicians		80				
	Student labor		0				
	Production burn-in and checkout	LV4140	480	23,706	4,000	0	27,706
	Engineers		80				
	Technicians		80				
	Student labor		320				
	Production diagnostics and repair	LV4150	320	30,994	4,000	0	34,994
	Engineers		160				
	Technicians		160				
	Student labor		0				
	Shipping	LV4210	40	2,411	19,200	0	21,611
	Engineers		0				
	Technicians		40				
	Student labor		0				

WBS 6.5.2.4

	Student labor		0				
	Basic checkout and burn-in	LV2040	**888**	33,888	0	0	33,888
	Engineers		0				
	Technicians		444				
	Student labor		444				
	Repairs	LV2050	**296**	19,305	0	2,000	21,305
	Engineers		0				
	Technicians		296				
	Student labor		0				
	Test Equipment	LV2070	**74**	4,344	15,000	0	19,344
	Engineers		0				
	Technicians		74				
	Student labor		0				
	Parts Procurement	LV2120	**167**	19,305	221,000	0	240,305
	Engineers		111				
	Technicians		56				
	Student labor		0				
	PCB Fab and assy	LV2130	**222**	11,757	110,000	6,000	127,757
	Engineers		0				
	Technicians		222				
	Student labor		0				
	Basic checkout and burn-in	LV2140	**8,066**	196,390	0	0	196,390
	Engineers		0				
	Technicians		962				
	Student labor		7,104				
	Repairs	LV2150	**475**	44,590	5,000	0	49,590
	Engineers		197				
	Technicians		278				